

Claims

What is claimed is:

1. A method of providing a checkpoint/restart facility across a plurality of plurality of computer systems, wherein:
the plurality of computer systems comprises:
a first computer system executing a first program, and
a second computer system containing a disk system and
executing a second program;
the first computer system and the second computer system are
heterogeneous computer systems;
said method comprising:
A) checkpointing a current status of the first program resulting in a
first set of checkpoint status information;
B) transmitting a first checkpoint request that includes the first set of
checkpoint status information from the first program over a first
session to the second program;
C) checkpointing the second program resulting in a second set of
checkpoint status information in response to receiving the first
checkpoint request;
D) writing the first set of checkpoint status information and the second
set of checkpoint status information to a first checkpoint file on
the disk system; and
E) transmitting a first checkpoint response from the second program
over the first session to the first program after the writing in
step (D) is complete.

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1 2. The method in claim 1 wherein:
2 the method further comprises:
3 F) checkpointing the first program resulting in a third set of
4 checkpoint status information;
5 G) transmitting a second checkpoint request that includes the third set
6 of checkpoint status information from the first program over the
7 first session to the second program;
8 H) checkpointing the second program resulting in a fourth set of
9 checkpoint status information in response to receiving the first
10 checkpoint request transmitted in step (G);
11 I) writing the third set of checkpoint status information and the fourth
12 set of checkpoint status information to a second checkpoint file
13 on the disk system; and
14 J) transmitting a second checkpoint response from the second
15 program over the first session to the first program after the
16 writing in step (I) is complete.

1 3. The method in claim 2 which further comprises:
2 J) transmitting a first rollback request from the first program over the
3 first session to the second program;
4 K) reading the third set of checkpoint status information and the
5 fourth set of checkpoint status information from the second
6 checkpoint file in response to receiving the first rollback
7 request transmitted in step (J);
8 L) rolling back the second program utilizing the fourth set of
9 checkpoint status information read in step (K);
10 M) transmitting a first rollback response from the second program
11 over the first session to the first program that includes the third
12 set of checkpoint status information read in step (K); and
13 N) rolling back the first program utilizing the third set of checkpoint
14 status information in response to receiving the first rollback
15 response in step (M).

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1 5. The method in claim 1 which further comprises:
2 F) transmitting a first rollback request from the first program over the
3 first session to the second program;
4 G) reading the first set of checkpoint status information and the
5 second set of checkpoint status information from the first
6 checkpoint file in response to receiving the first rollback
7 request transmitted in step (F);
8 H) rolling back the second program utilizing the second set of
9 checkpoint status information read in step (G);
10 I) transmitting a first rollback response from the second program
11 over the first session to the first program that includes the first
12 set of checkpoint status information read in step (G);
13 J) rolling back the first program utilizing the first set of checkpoint
14 status information in response to receiving the first rollback
15 response in step (I).

6. The method in claim 1 which further comprises:

- F) transmitting a second checkpoint request that includes the first set of checkpoint status information from the first program over a second session to a third program executing in a third computer system;
- G) checkpointing the third program resulting in a fourth set of checkpoint status information in response to receiving the second checkpoint request;
- H) writing the first set of checkpoint status information and the fourth set of checkpoint status information to a second checkpoint file; and
- I) transmitting a second checkpoint response from the third program over the second session to the first program after the writing in step (H) is complete.

- 1 7. The method in claim 6 which further comprises:
2 J) transmitting a first rollback request from the program over the first
3 session to the second program;
4 K) reading the first set of checkpoint status information and the
5 second set of checkpoint status information from the first
6 checkpoint file in response to receiving the first rollback
7 request transmitted in step (J);
8 L) rolling back the second program utilizing the second set of
9 checkpoint status information read in step (K);
10 M) transmitting a first rollback response from the second program
11 over the first session to the first program that includes the first
12 set of checkpoint status information read in step (K); and
13 N) rolling back the first program utilizing the first set of checkpoint
14 status information in response to receiving the first rollback
15 response transmitted in step (M).

1 8. The method in claim 6 which further comprises:

2 J) transmitting a first rollback request from the program over the first
3 session to the second program;

4 K) reading the first set of checkpoint status information and the
5 second set of checkpoint status information from the first
6 checkpoint file in response to receiving the first rollback
7 request transmitted in step (J);

8 L) rolling back the second program utilizing the second set of
9 checkpoint status information read in step (K);

10 M) transmitting a first rollback response from the second program
11 over the first session to the first program that includes the first
12 set of checkpoint status information read in step (K);

13 O) transmitting a second rollback request from the first program over
14 the second session to the third program;

15 P) reading the first set of checkpoint status information and the fourth
16 set of checkpoint status information from the second checkpoint
17 file in response to receiving the second rollback request
18 transmitted in step (O);

19 Q) rolling back the third program utilizing the fourth set of checkpoint
20 status information read in step (P);

21 R) transmitting a second rollback response from the third program
22 over the second session to the first program that includes the
23 first set of checkpoint status information read in step (P); and

24 S) rolling back the first program utilizing the first set of checkpoint
25 status information in response to receiving the first rollback
26 response transmitted in step (M) and the second rollback
27 response transmitted in step (R).

1 9. The method in claim 1 wherein:

2 there are plurality of sessions open between the first program and the
3 second program for accessing a corresponding plurality of files
4 by the second program; and

5 the checkpointing in step (C) flushes all of the plurality of files and
6 includes checkpoint information for all of the plurality of files
7 in the second set of checkpoint information.

- 1 10. A computer readable Non-Volatile Storage Medium encoded with
2 software for providing a checkpoint/restart facility across a plurality
3 of plurality of computer systems, wherein:
4 the plurality of computer systems comprises:
5 a first computer system executing a first program, and
6 a second computer system containing a disk system and
7 executing a second program;
8 the first computer system and the second computer system are
9 heterogeneous computer systems;
10 said software comprising:
11 A) a set of computer instructions for checkpointing a current status of
12 the first program resulting in a first set of checkpoint status
13 information;
14 B) a set of computer instructions for transmitting a first checkpoint
15 request that includes the first set of checkpoint status
16 information from the first program over a first session to the
17 second program;
18 C) a set of computer instructions for checkpointing the second
19 program resulting in a second set of checkpoint status
20 information in response to receiving the first checkpoint
21 request;
22 D) a set of computer instructions for writing the first set of checkpoint
23 status information and the second set of checkpoint status
24 information to a first checkpoint file on the disk system; and
25 E) a set of computer instructions for transmitting a first checkpoint
26 response from the second program over the first session to the
27 first program after the writing in set (D) is complete.

11. A data processing system having software stored in a set of Computer Software Storage Media for providing a checkpoint/restart facility across a plurality of plurality of computer systems, wherein: the data processing system comprises the plurality of computer systems;

the plurality of computer systems comprises:

- a first computer system executing a first program, and
- a second computer system containing a disk system and executing a second program;

the first computer system and the second computer system are heterogeneous computer systems;

said software comprising:

- A) a set of computer instructions for checkpointing a current status of the first program resulting in a first set of checkpoint status information;
- B) a set of computer instructions for transmitting a first checkpoint request that includes the first set of checkpoint status information from the first program over a first session to the second program;
- C) a set of computer instructions for checkpointing the second program resulting in a second set of checkpoint status information in response to receiving the first checkpoint request;
- D) a set of computer instructions for writing the first set of checkpoint status information and the second set of checkpoint status information to a first checkpoint file on the disk system; and
- E) a set of computer instructions for transmitting a first checkpoint response from the second program over the first session to the first program after the writing in set (D) is complete.

- 1 12. The software in claim 11 wherein:
2 the software further comprises:
3 F) a set of computer instructions for checkpointing the first program
4 resulting in a third set of checkpoint status information;
5 G) a set of computer instructions for transmitting a second checkpoint
6 request that includes the third set of checkpoint status
7 information from the first program over the first session to the
8 second program;
9 H) a set of computer instructions for checkpointing the second
10 program resulting in a fourth set of checkpoint status
11 information in response to receiving the first checkpoint request
12 transmitted in set (G);
13 I) a set of computer instructions for writing the third set of
14 checkpoint status information and the fourth set of checkpoint
15 status information to a second checkpoint file on the disk
16 system; and
17 J) a set of computer instructions for transmitting a second checkpoint
18 response from the second program over the first session to the
19 first program after the writing in set (I) is complete.

- 1 13. The software in claim 12 which further comprises:
2 J) a set of computer instructions for transmitting a first rollback
3 request from the first program over the first session to the
4 second program;
5 K) a set of computer instructions for reading the third set of
6 checkpoint status information and the fourth set of checkpoint
7 status information from the second checkpoint file in response
8 to receiving the first rollback request transmitted in set (J);
9 L) a set of computer instructions for rolling back the second program
10 utilizing the fourth set of checkpoint status information read in
11 set (K);
12 M) a set of computer instructions for transmitting a first rollback
13 response from the second program over the first session to the
14 first program that includes the third set of checkpoint status
15 information read in set (K); and
16 N) a set of computer instructions for rolling back the first program
17 utilizing the third set of checkpoint status information in
18 response to receiving the first rollback response in set (M).
- 1 14. The software in claim 12 wherein:
2 the first checkpoint file and the second checkpoint file are a same file.

15. The software in claim 11 which further comprises:

- F) a set of computer instructions for transmitting a first rollback request from the first program over the first session to the second program;
- G) a set of computer instructions for reading the first set of checkpoint status information and the second set of checkpoint status information from the first checkpoint file in response to receiving the first rollback request transmitted in set (F);
- H) a set of computer instructions for rolling back the second program utilizing the second set of checkpoint status information read in set (G);
- I) a set of computer instructions for transmitting a first rollback response from the second program over the first session to the first program that includes the first set of checkpoint status information read in set (G);
- J) a set of computer instructions for rolling back the first program utilizing the first set of checkpoint status information in response to receiving the first rollback response in set (I).

1 16. The software in claim 11 which further comprises:
2 F) a set of computer instructions for transmitting a second checkpoint
3 request that includes the first set of checkpoint status
4 information from the first program over a second session to a
5 third program executing in a third computer system;
6 G) a set of computer instructions for checkpointing the third program
7 resulting in a fourth set of checkpoint status information in
8 response to receiving the second checkpoint request;
9 H) a set of computer instructions for writing the first set of checkpoint
10 status information and the fourth set of checkpoint status
11 information to a second checkpoint file; and
12 I) a set of computer instructions for transmitting a second checkpoint
13 response from the third program over the second session to the
14 first program after the writing in set (H) is complete.

- 1 17. The software in claim 16 which further comprises:
2 J) a set of computer instructions for transmitting a first rollback
3 request from the program over the first session to the second
4 program;
5 K) a set of computer instructions for reading the first set of checkpoint
6 status information and the second set of checkpoint status
7 information from the first checkpoint file in response to
8 receiving the first rollback request transmitted in set (J);
9 L) a set of computer instructions for rolling back the second program
10 utilizing the second set of checkpoint status information read in
11 set (K);
12 M) a set of computer instructions for transmitting a first rollback
13 response from the second program over the first session to the
14 first program that includes the first set of checkpoint status
15 information read in set (K); and
16 N) a set of computer instructions for rolling back the first program
17 utilizing the first set of checkpoint status information in
18 response to receiving the first rollback response transmitted in
19 set (M).

1 18. The software in claim 16 which further comprises:

2 J) a set of computer instructions for transmitting a first rollback
3 request from the program over the first session to the second
4 program;

5 K) a set of computer instructions for reading the first set of checkpoint
6 status information and the second set of checkpoint status
7 information from the first checkpoint file in response to
8 receiving the first rollback request transmitted in set (J);

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9      L) a set of computer instructions for rolling back the second program
10         utilizing the second set of checkpoint status information read in
11         set.(K);

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12 M) a set of computer instructions for transmitting a first rollback
13 response from the second program over the first session to the
14 first program that includes the first set of checkpoint status
15 information read in set (K);

16 O) a set of computer instructions for transmitting a second rollback
17 request from the first program over the second session to the
18 third program;

19 P) a set of computer instructions for reading the first set of checkpoint
20 status information and the fourth set of checkpoint status
21 information from the second checkpoint file in response to
22 receiving the second rollback request transmitted in set (O);

23 Q) a set of computer instructions for rolling back the third program
24 utilizing the fourth set of checkpoint status information read in
25 set (P);

26 R) a set of computer instructions for transmitting a second rollback
27 response from the third program over the second session to the
28 first program that includes the first set of checkpoint status
29 information read in set (P); and

30 S) a set of computer instructions for rolling back the first program
31 utilizing the first set of checkpoint status information in
32 response to receiving the first rollback response transmitted in
33 set (M) and the second rollback response transmitted in set (R).

- 1 19. The software in claim 11 wherein:
2 there are plurality of sessions open between the first program and the
3 second program for accessing a corresponding plurality of files
4 by the second program; and
5 the checkpointing in set (C) flushes all of the plurality of files and
6 includes checkpoint information for all of the plurality of files
7 in the second set of checkpoint information.
- 1 20. A data processing system having software stored in a set of Computer
2 Software Storage Media for providing a checkpoint/restart facility
3 across a plurality of plurality of computer systems, wherein:
4 the data processing system comprises the plurality of computer
5 systems;
6 the plurality of computer systems comprises:
7 a first computer system executing a first program, and
8 a second computer system containing a disk system and
9 executing a second program;
10 the first computer system and the second computer system are
11 heterogeneous computer systems;
12 said software comprising:
13 A) means for checkpointing a current status of the first program
14 resulting in a first set of checkpoint status information;
15 B) means for transmitting a first checkpoint request that includes the
16 first set of checkpoint status information from the first program
17 over a first session to the second program;
18 C) means for checkpointing the second program resulting in a second
19 set of checkpoint status information in response to receiving the
20 first checkpoint request;
21 D) means for writing the first set of checkpoint status information and
22 the second set of checkpoint status information to a first
23 checkpoint file on the disk system; and
24 E) means for transmitting a first checkpoint response from the second
25 program over the first session to the first program after the
26 writing in set (D) is complete.